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PERMIAN TETHYAN FUSULININA FROM THE KENAI PENINSULA, ALASKA

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ABSTRACT—Two samples from a large, allochthonous limestone block in the McHugh Complex of the Chugach terrane on the Kenai Peninsula, Alaska, contain species of 12 genera of Permian Fusulinina including *Abadehella*, *Kahlerina*, *Pseudokahlerina*?, *Nankinella*, *Codonofusiella*, *Dunbarula*, *Parafusulina*?, *Chusenella*, *Verbeekina*, *Pseudodoliolina*, *Metadoliolina*?, *Sumatrina*?, and *Yabeina*, as well as several other foraminiferans and one alga. The assemblage of fusulinids is characteristically Tethyan, belonging to the *Yabeina archaica* zone of early Midian (late Wordian) age. Similar faunas are known from the Pamirs, Transcaucasia, and Japan, as well as from allochthonous terranes in British Columbia, northwestern Washington, and Koryakia in eastern Siberia.

INTRODUCTION

TWO-SAMPLES bearing Permian fusulinaceans were collected from a large limestone block in the McHugh Complex along the eastern wall of Petrof Glacier, about 3.5 km north of its terminus along the southeast coast of the Kenai Peninsula in the Seldovia quadrangle (Figure 1). These fossils are important in that they show that the block in which they occur was derived from a shallow-water, tropical, western Pacific, Permian, carbonate platform prior to being incorporated into the subduction complex, along with other blocks of vastly different ages and environments.

The McHugh Complex of south-central Alaska is part of a vast subduction complex of Mesozoic age—the Chugach terrane—exposed along the margin of the Gulf of Alaska. It is named for exposures near Anchorage (Clark, 1972) which consist of a tectonic melange of greenstone, chert, argillite, graywacke, and conglomerate, plus rare blueschist, gabbro, ultramafic rocks, and, the focus of this paper, limestone. Equivalent rocks on Kodiak Island are assigned to the Uyak Complex (Connelly, 1978). In the USGS 1:250,000-scale Seldovia quadrangle, where the McHugh Complex has been studied in greatest detail, it has an outcrop width of 40 km (Bradley and Kusky, 1992), and consists of a deformed argillite matrix that encloses blocks from several kilometers across down to hand-sample size and smaller of the rock types listed above.

Most of the fossil control for the McHugh Complex has come from radiolarian chert. Intensive sampling of chert from the Seldovia quadrangle has disclosed ages ranging from Ladinian (Middle Triassic) to Albian–Aptian (mid-Cretaceous) according to C. Blome (personal commun., 1994). The span of ages from the Seldovia quadrangle is consistent with, but more complete than, ages previously reported from the Anchorage quadrangle (Nelson et al., 1987), the Valdez quadrangle (Winkler et al., 1981), and Kodiak and adjacent islands (Connelly, 1978). One sample from Kodiak Island yielded cryptoceptic Nassellariina forms (Connelly, 1978; identification by E. Pessagno), originally considered Paleozoic; however, the lower range of nasselarians is now known to be in the Triassic (B. Murchey, personal commun., 1996).

Blocks of limestone, including those containing the fusulinaceans described here, are scattered throughout the Chugach terrane. Most of the dated blocks are Permian in age, but one from a conglomerate in the McHugh Complex in the Anchorage quadrangle has yielded conodonts with a possible age of late Meramecian to early Morrowan (Late Mississippian to Early Pennsylvanian). Nelson et al. (1986) suggested that this clast could have been derived from the Strelna Formation of the Wrangellia terrane. In the Seldovia quadrangle, the distribution of limestone blocks shows no regional pattern. Blocks range in size from subequant lozenges a few centimeters across, to fragments of formations 50–100 m thick and 100–200 m long. Typically, the limestone blocks are surrounded by phacoidally cleaved argillite; none has yet been found in stratigraphic contact with adjacent rocks. Some limestones occur in long strings of boudins, suggesting extensional disruption of initially continuous layers.

In addition to the Permian fusulinid-bearing limestone block that is the focus of this paper, two other limestone blocks in the Seldovia quadrangle have yielded Permian conodonts of Tethyan

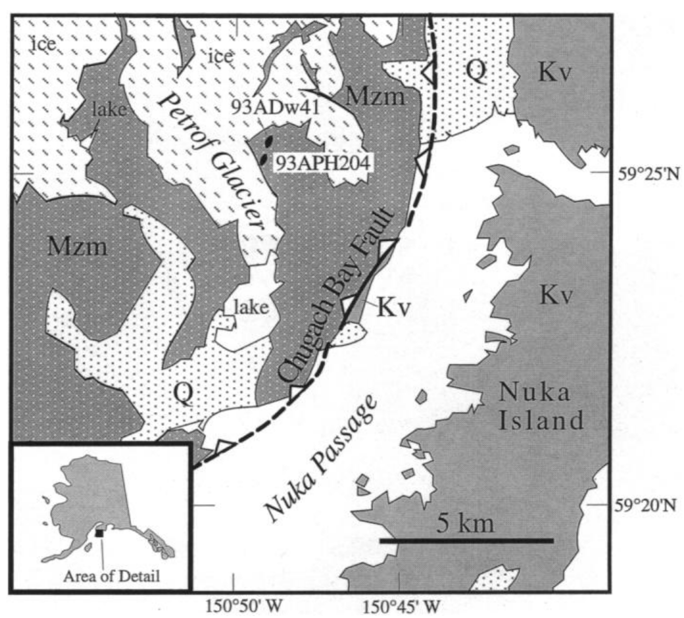
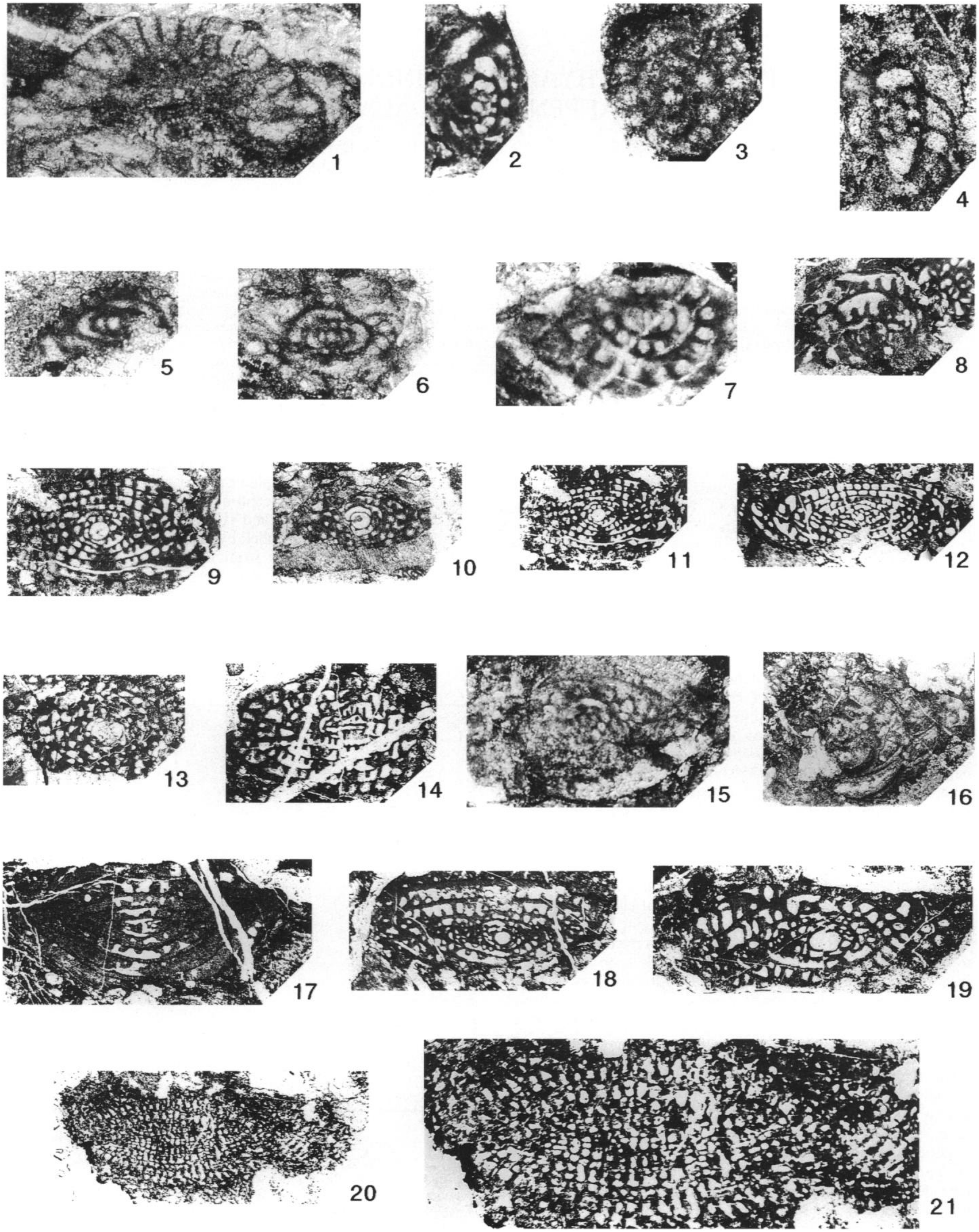


FIGURE 1—Simplified geologic map of a portion of the Seldovia 1: 250,000 quadrangle, south-central Alaska (from Bradley and others, in prep.) Limestone blocks are shown in black; station 93ADw41 contained the Permian fusulinids described herein; station 93APH204 has yielded Permian conodonts. Mzm is McHugh Complex; Kv is Cretaceous Valdez Group; Q is Quaternary cover.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affinity; both conodont faunas are Wuchiapingian (Late Permian) in age (B. Wardlaw and A. Harris, written commun., 1994). One of these blocks (93APH204 in Figure 1) is less than 1 km from, and on strike with, the fusulinid-bearing limestone (93ADw41 in Figure 1). Clark (1972) previously reported the presence of schwagerinid fusulinids and the Tethyan neoschwagerinid *Cancellina* in the Chugach Mountains near Anchorage. On Kodiak Island, Connelly (1978) reported one limestone block in the Uyak Complex (part of the Chugach terrane) as containing a mid-Permian Tethyan fossil assemblage including *Neoschwagerina, Cancellina?, Codonofusiella, Colaniella, Pachyphloia, Nodosinella*, and a dasycladacean alga, and another block containing interbedded tuff and yielding *Neoschwagerina* (identifications by G. Wilde).

FOSSIL ASSEMBLAGE

Permian fossils have been recovered from two small samples from the large limestone block in the McHugh Complex at the locality on the east side of Petrof glacier (Figure 1). The diversity of sample 93ADw41A is low, consisting of nine recognized species. Two species of *Yabeina* and one species of *Nankinella* represent the fusulinids. In addition, at least five species of smaller foraminifers probably belonging to the genera *Lunucammina* and *Agathamina* and one species of alga, probably *Mizzia*, are present. The second sample, 93ADw41B, contains the foraminiferan *Pachyphloia* and a much richer assemblage of Fusulinina including species of the genera *Abadehella, Kahlerina, Pseudokahlerina?, Codonofusiella, Dunbarula, Parafusulina?, Chusenella, Verbeekina, Pseudodoliolina, Metadoliolina?, Sumatrina?*, and *Yabeina*. Species of all of these genera are briefly described except for the form assigned to *Pseudokahlerina?* because it is represented by only one very poorly preserved and oriented specimen. It is differentiated from *Kahlerina*, however, because the axial length apparently exceeds the diameter.

Thin sections of all specimens have been retained in the Museum of Paleontology, Department of Geology, San Jose State University.

SYSTEMATIC PALEONTOLOGY

Order FORAMINIFERIDA Eichwald, 1830
Suborder FUSULININA Wedekind, 1937
Superfamily ENDOTHYRACEA Brady, 1884
Genus ABADEHELLA Okimura, Ishii, and Nakazawa, 1975
ABADEHELLA sp.
Figure 2.1

Description.—Test subconical, diameter about 0.6 mm. Wall very thin, dark, microgranular. Septa numerous, well developed.

Discussion.—Only one oblique, almost sagittal section is available for study.

Occurrence.—Sample 93ADw41B.

Genus KAHLERINA Kochansky-Devidé and Ramovš, 1955
KAHLERINA sp.
Figure 2.3, 2.4

Description.—Test very small, enrolled, broadly discoidal, diameter (D) 0.2–0.5 mm, axial length (AL) 0.1–0.45 mm, D:AL = 1 or less; first volutions have staffelloid form. Wall thin, perhaps microgranular, with two layers.

Discussion.—Five specimens are present in the samples studied. These specimens are considered primitive because of their small size, the presence of only 3–4 volutions, and the thinness of the wall.

Occurrence.—Sample 93ADw41B.

Superfamily FUSULINACEA von Möller, 1878
Genus NANKINELLA Lee, 1933
NANKINELLA sp.
Figure 3.4, 3.5, 3.8, 3.9

Description.—Test composed of 5–6 volutions, axial length up to 0.68 mm and diameter 1.0 mm; periphery rather gently rounded in early volutions, sharply rounded in last volution; septa straight, about 22 in penultimate volution.

Discussion.—Numerous specimens of *Nankinella* are available for study, but most are poorly oriented and all are completely recrystallized.

Occurrence.—Sample 93ADw41A and 93ADw41B.

Genus CODONOFUSIELLA Dunbar and Skinner, 1937
CODONOFUSIELLA sp.
Figure 2.15

Description.—Test with three volutions, very small, axial length about 1.1 mm, and diameter 0.38 mm, melon-shaped with sharply pointed poles. First volution slightly evolute; third volution relatively higher than earlier volutions and coiled almost normal to them. Proloculus minute, but not smaller than 0.04 mm. Spirotheca thin, composed of very thin, dark tectum and a dense, apparently structureless layer. Septa highly and irregularly fluted throughout test. Tunnel narrow; high, well developed pseudochomata present in all volutions.

Discussion.—The single described specimen is partly crushed so some important features could not be recognized. We include this specimen in the genus *Codonofusiella* because of its small size, schubertellid-like wall structure, fluted septa, and some unrolling of the last volution. This specimen is similar to *Codonofusiella duffelli* Thompson, Wheeler, and Danner, 1950 from British Columbia, differing only in the lack of the high, unrolled last volution which is characteristic of *C. duffelli*.

Occurrence.—Sample 93ADw41B.

Genus DUNBARULA Ciry, 1948
DUNBARULA sp.
Figure 2.5–2.7

Description.—Test with 3–4 volutions, very small; last volution coils perpendicular to inner volutions. Diameter = 0.35–0.5mm, axial length = 0.2–0.3mm; D:AL = 1.3–2.0. Septa mostly straight, bent in polar regions. Small chomata in inner two volutions.

Discussion.—The seven Alaskan specimens observed are very primitive and resemble specimens from British Columbia described by Thompson et al. (1950, pl. 4, fig. 7) as (?)*Codonofusiella duffelli*. They also are similar to *D. laudoni* Skinner and Wilde, 1966a from northwestern Washington and *D. nana* Kochansky-Devidé and Ramovš, 1955 from Yugoslavia, differing from the latter species in possessing an elongate test and having tightly coiled outer volutions.

Occurrence.—Sample 93ADw41B.

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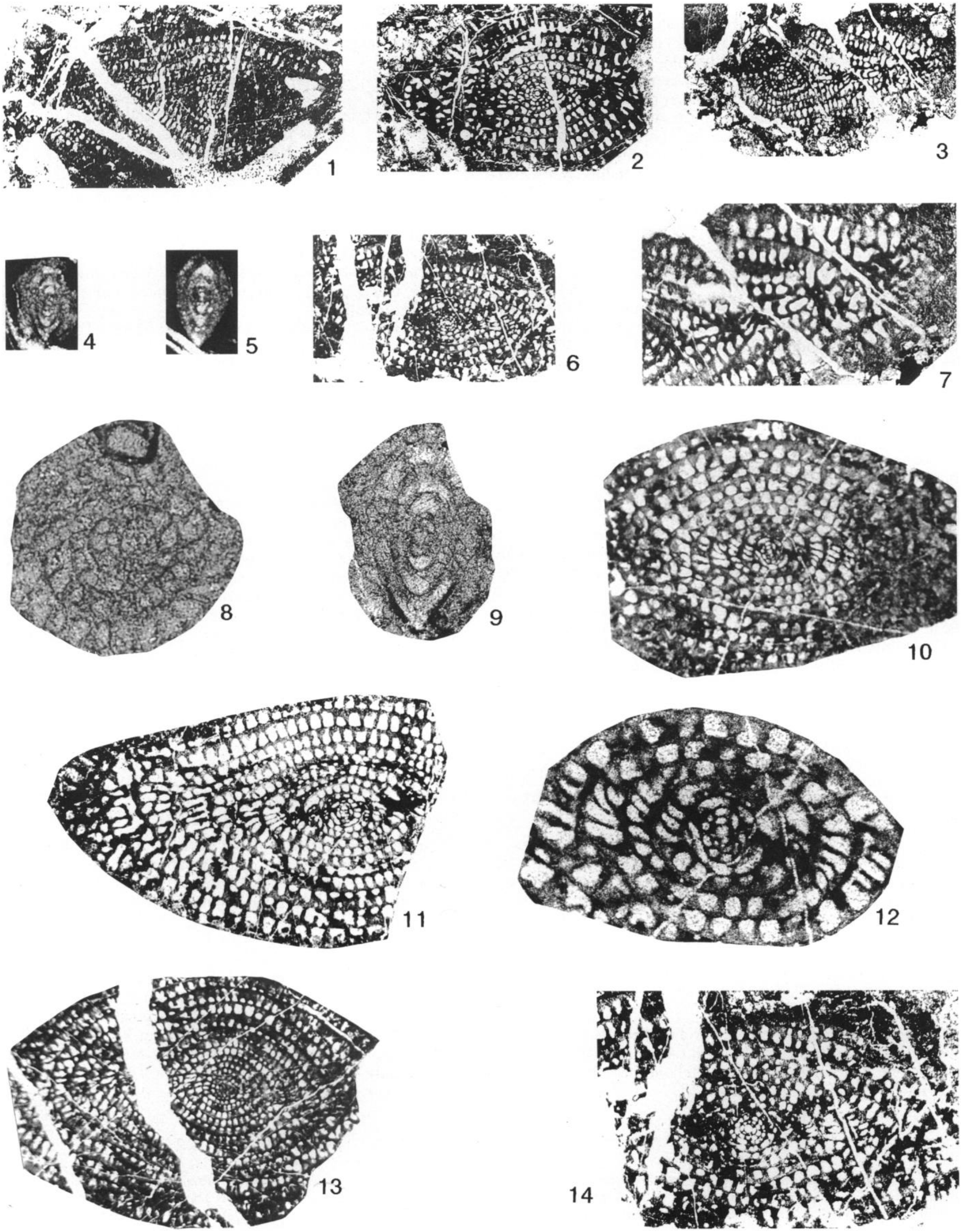
FIGURE 2—Fusulinina from the McHugh Complex, field sample number 93ADw41B. *1, Abadehella* sp., ×100; *2, Pseudokahlerina?* sp., ×100; *3,4, Kahlerina* sp., ×100; *5–7, Dunbarula* sp., ×100; *8, Metadoliolina?* sp., ×20; *9–14, Pseudodoliolina oliviformis* Thompson, Wheeler, and Danner, 1950, *9,10,13*, ×20, *11,12,14*, ×15; *15, Codonofusiella* sp., ×100; *16, Verbeekina* sp., ×20; *17, Chusenella* ex gr. *C. atlinensis* (Ross, 1971), ×15; *18,19, Parafusulina?* sp., ×15; *20,21, Sumatrina?* sp., ×15, ×30.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Genus PARAFUSULINA Dunbar and Skinner, 1936
PARAFUSULINA? sp.
Figure 2.18, 2.19

Description.—All specimens have only 3–4 uncrushed volutions which are inflated and fusiform with sharply pointed poles. Proloculus very large with outside diameter of 0.25–0.4 mm. Spirotheca thick and distinctly alveolar; septa intensely fluted throughout with fluting extending to top of chambers. Tunnel narrow and low. Axial filling absent or forming a narrow band along the axis.

Discussion.—The five specimens recovered are similar to *P. japonica* (Gumbel, 1878) from the Akasaka Limestone in Japan in the shape of the test, character of coiling, large proloculus, character of septal fluting, and absence of axial filling.

Occurrence.—Sample 93ADw41B.

Genus CHUSENELLA Hsu, 1942
CHUSENELLA ex gr. ATLINENSIS (Ross, 1971)
Figure 2.17

Schwagerina atlinensis ROSS, 1971, p. 97, Pl. 17, figs. 1–5.

Description.—Test fusiform with acutely pointed poles, inflated in central area. First volutions apparently low and elongate, gradually increasing in height and becoming spindle-shaped. Spirotheca composed of thin tectum and coarsely alveolar keriotheca, thickness increases gradually in inner volutions, but increases markedly in outer two volutions where it has an undulating form. Septa intensely and regularly fluted; in axial sections they form subquadrate arches approximately one-half volution in height. Tunnel slightly irregular; chomata not recognized; axial filling massive in the axial region in all volutions.

Discussion.—The single Alaskan specimen is very similar to *C. atlinensis* (Ross, 1971) from British Columbia in the size and shape of the test, the wall structure (especially the undulating character of the wall in the last two volutions), and character of septal fluting and axial filling. An unqualified identification is not possible because the inner volutions in the Alaskan specimen are not present.

Occurrence.—Sample 93ADw41B.

Family VERBEEKINIDAE Staff and Wedekind, 1910
Genus VERBEEKINA Staff 1909
VERBEEKINA sp.
Figure 2.16

Description.—Test almost spherical, large, three outer volutions very loosely coiled. Septa straight. Spirotheca relatively thin, structure obscured by silicification, but probably with alveolar keriotheca. No parachomata have been recognized.

Discussion.—Two poorly preserved, silicified specimens are represented by oblique sections. The almost spherical tests, loose coiling, straight septa, and absence of parachomata, however, indicate the genus *Verbeekina*. The Alaskan specimens are closely related to well-developed species of *Verbeekina*, such as *V. verbeeki* (Geinitz, 1876).

Occurrence.—Sample 93ADw41B.

Genus PSEUDODOLIOLINA Yabe and Hanzawa 1932
PSEUDODOLIOLINA OLIVIFORMIS
Thompson, Wheeler, and Danner, 1950
Figure 2.9–2.14

Pseudodoliolina oliviformis THOMPSON, WHEELER, AND DANNER, 1950, p. 58, Pl. 5, figs. 7–11.

Description.—Test with as many as 12 volutions, elongate, ellipsoidal, with rounded polar areas. Specimen of 8 volutions 3 mm long, 1.2 mm in diameter, giving a form ratio of 2.5. Coiling tight, regular. Proloculus relatively large, 0.15–0.25 mm. Spirotheca very thin, composed of thin, dark tectum and relatively thick, fine, dense, inner layer. Parachomata in all volutions narrow and high.

Discussion.—The 10 specimens described here are similar to *Pseudodoliolina oliviformis* Thompson, Wheeler and Danner, 1950 from British Columbia in size, shape of test, large diameter of proloculus, thinness of spirotheca, and form of parachomata.

Occurrence.—Sample 93ADw41B.

Genus METADOLIOLINA Ishii and Nogami, 1961
METADOLIOLINA? sp.
Figure 2.8

Description.—Test subspherical, polar regions broadly rounded, slightly umbilicate. Coiling tight, but looser than in any species of *Pseudodoliolina*. Spirotheca relatively thick, composed of a thin, dark tectum; keriotheca with fine alveoli (?); and a dense inner layer. Parachomata numerous, well developed in all volutions, narrow, and about one-half volution high.

Discussion.—The Alaskan specimen is assigned to *Metadoliolina*? rather than *Pseudodoliolina* because of its subspherical test; its thick, three-layered spirotheca; parachomata that are lower than those of *Pseudodoliolina*; and the relatively loose coiling.

Occurrence.—Sample 93ADw41B.

Genus SUMATRINA Volz, 1904
SUMATRINA? sp.
Figure 2.20, 2.21

Description.—Test fusiform with bluntly pointed poles. More than 10 volutions. At last volution test 4.1 mm long, 1.3 mm wide, with form ratio of 3.15. At sixth from outermost volution, test 0.8 mm long, 0.4 mm wide, with form ratio of 2.0. Spirotheca very thin, 0.005–.01 mm in last volution, composed of single compact layer. Primary transverse septula developed throughout test, joined to tops of parachomata. One or two secondary transverse septula between adjacent primary transverse septula. Parachomata narrow, low.

Discussion.—Only one tangential section is available for study. This specimen is similar to *Sumatrina fusiformis* Sheng, 1958 from south China in the shape of the test, size, and wall structure. The Alaskan specimen, however, has fewer secondary transverse septula in the outer volution than *S. fusiformis*.

Occurrence.—Sample 93ADw41B.

Genus YABEINA Deprat, 1914
YABEINA sp. A
Figures 3.1–3.3, 3.7, 4.1, 4.4

Description.—Shell, elongate, at least 10 volutions; maximum length 5.1 mm, diameter 2.3 mm, with form ratio of 2.2. In sixth volution, 3.2 mm long, 1.5 mm wide, giving form ratio of 2.1. Spirotheca about .024 mm thick, consists of tectum and thin keriotheca. Secondary septula very small, short, first present in fourth volution, but occur irregularly even in outermost volutions. Proloculus small, .073–.087 mm. Wall thick, septa and septula somewhat triangular.

Discussion.—*Yabeina* sp. A is similar to *Y. moncropensis*

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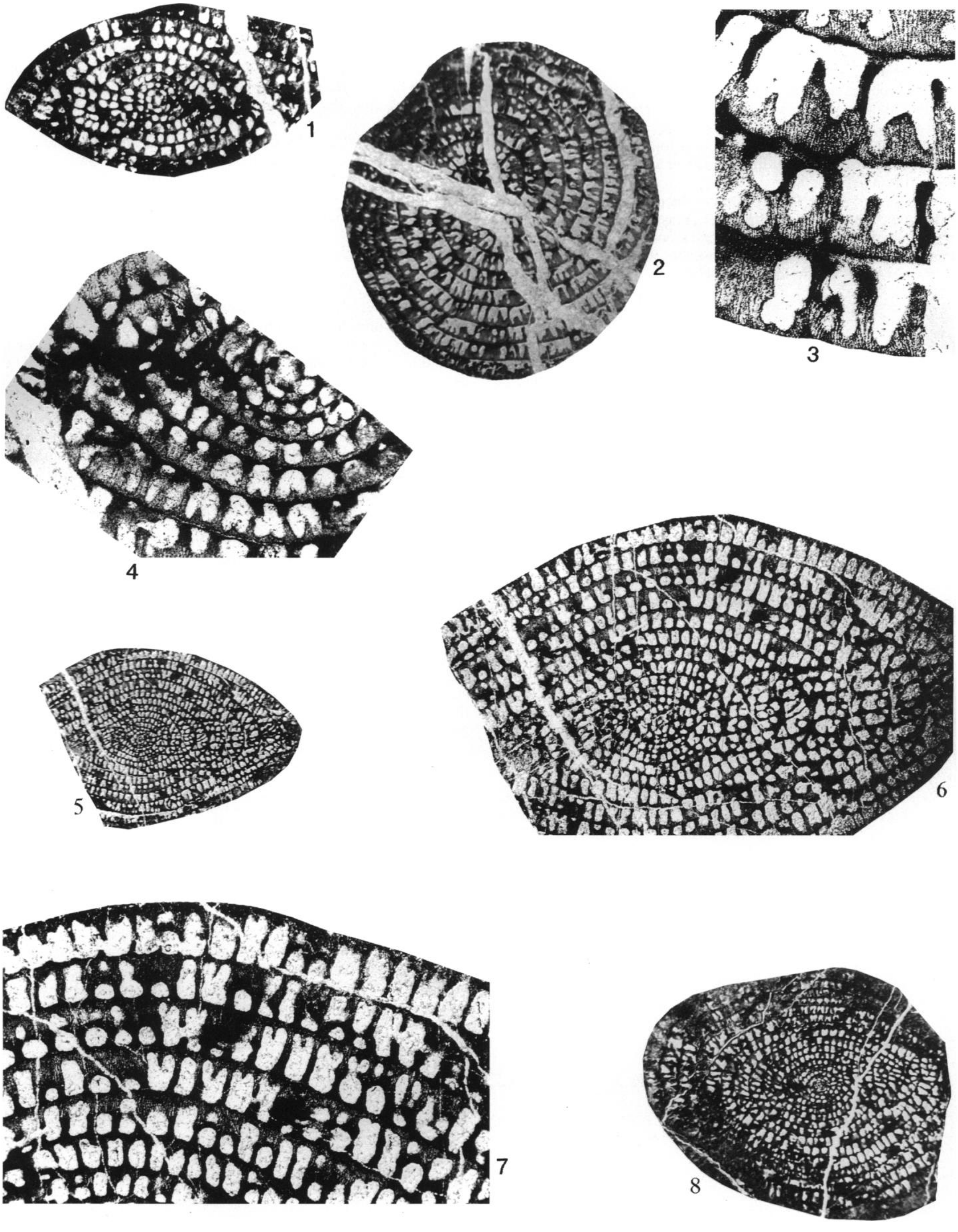
FIGURE 3—Permian fusulinids from the McHugh Complex, *1–3* from field sample 93ADw41B; remainder from field sample number 93ADw41A. *1–3,7*, *Yabeina* sp. A, *1–3* ×15, *7* ×60; *4,5,8,9*, *Nankinella* sp., *4,5* ×25, *8,9* ×45 (*4,9*, same specimen); *6,10–14*, *Yabeina* sp. B, *6,13* ×15, *10,11,14* ×25, *12*, ×45 (*6,14*, same specimen; *10,12*, same specimen).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Thompson, Wheeler, and Danner, 1950 from British Columbia, except that secondary septula are more common in the specimens from Alaska. The Alaskan specimens are very similar to *Y. cordillerensis* Ross, 1971 from British Columbia and *Y. decora* Skinner and Wilde, 1966a from northwestern Washington, but we do not have enough material to make a definite identification.

In regards to the definition of *Yabeina* and the age of some western North American faunas containing this genus, we differ from Lin Rui and Nassichuk (1996) in several respects. We consider that the many species from the Cache Creek rocks previously assigned to *Yabeina*, including *Y. columbiana* (Dawson, 1879), are correctly assigned. The presence of secondary transverse septula is very important in separation of *Yabeina* from *Colania*, the assignment made by Lin Rui and Nassichuk (1996). Except in a few species transitional to *Lepidolina*, that occur in rocks higher than upper Wordian (or lower Midian), these septula are lacking in *Colania*.

We also consider *Yabeina columbiana* to be younger than the morphologically similar *Y. cordillerensis* Ross, 1971 and *Y. nakinensis* Ross, 1971. *Y. columbiana*, from the Marble Canyon area is larger than the others, has more volutions, and has 6–7 axial septula between the septa. *Y. cordillerensis* and *Y. nakinensis* have only 2–3 axial septula between septa. The very advanced *Yabeina* and *Lepidolina* of the *L. shiraiwensis* Ozawa, 1925-type with which *Y. columbiana* occurs (Thompson and Wheeler, 1942; Thompson et al., 1950; Skinner and Wilde, 1966) also indicate a younger (late Midian or Capitanian) age. Thus, we agree with Monger and Ross (1971) that the fauna from the Marble Canyon area is younger than that from the Atlin area which compares well with the fauna described here.

Occurrence.—Sample 93ADw41A and 93ADw41B.

YABEINA sp. B
Figures 3.6, 3.10–3.14, 4.2, 4.3, 4.5–4.8

Description.—Shell highly inflated, up to 16 volutions, most with 12 or 13. Maximum length about 6.2 mm, diameter 4.0 mm, form ratio 1.9 to 2.3. Secondary septula small, short, appear as early as fifth volution, present consistently in later volutions. Proloculus about 0.05 mm followed by small staffelloid juvenarium composed of two or three whorls coiled at approximately right angles to remainder of shell. Wall about 0.024 mm thick, keriothecal wall structure well formed.

Discussion.—The innermost 6–7 volutions in *Yabeina* sp. B are more subspherical shape than in *Y.* sp. A, and staffelloid juvenarium is consistently present in *Y.* sp. B. *Y. cascadensis* (Anderson, 1941) and *Y. fusiformis* Skinner and Wilde, 1966a from northwestern Washington, *Y. nakinensis* Ross, 1971 from British Columbia, and *Y. ozawai* Honjo, 1959 from the *Neoschwagerina margaritae* zone of the Akasaka Limestone of Japan are also similar to *Y.* sp. B.

Occurrence.—Sample 93ADw41A, 93ADw41B.

AGE AND CORRELATION

The presence of *Yabeina* in both samples from Alaska (93ADw41A and 93ADw41B) shows that the faunas belong to the *Yabeina–Lepidolina* genozone or its equivalent (the Midian stage in the Tethys), which has been subdivided into two zones: the lower *Y. archaica* zone and the upper *Y. globosa* zone (Davydov, 1994; Table 1).

Specimens of *Yabeina* from both samples from Alaska are considered to be primitive because the secondary septula in both species first appear in the fourth or fifth volutions and the tests are relatively small. Similar species of *Yabeina* include *Y. ozawai* Honjo, 1959 from the Akasaka Limestone of Japan; *Y. archaica* Dutkevich, 1967 from the lower portion of the Karasin Formation; and *Y. cordillerensis* Ross, 1971, *Y. nakinensis* Ross, 1971, and *Y. moncropensis* Thompson, Wheeler, and Danner, 1950 from British Columbia. All of these species of *Yabeina* are considered to belong to the *Y. archaica* zone of the lower Midian (upper Wordian). Other Fusulinina that characterize this zone are *Neoschwagerina margaritae* (Deprat, sensu Ozawa, 1925), advanced species of *Verbeekina*, such as *V. verbeeki* (Geinitz, 1876), and the first occurrences of *Colania* (*Gifuella*), *Sumatrina annae* Volz, 1904, *Dunbarula* (*D. schubertellaeformis* Sheng, 1958), *D. nana* Kochansky-Devidé and Ramovš, 1955, *Kahlerina*, *Rauserella*, and *Abadehella*.

Overall the Fusulinina from the Alaska samples are similar taxonomically and morphologically with those of the Karasin Formation of the Pamirs (Davydov, 1994), the Arpa Formation of Transcaucasia (Kotlyar et al., 1989), the upper Wordian limestones of British Columbia (Ross, 1971) and northwestern Washington (Skinner and Wilde, 1966a), the *N. margaritae* zone in the Akasaka Limestone in Japan (Honjo, 1959), and the Permian limestones with *Colania kwangsiana* Lee, 1933 and *Neoschwagerina hanaokensis* Morikawa and Suzuki, 1961 from the Koryak terrane (Davydov et al., 1996), as shown in Table 1. Based upon these similarities, the occurrence of *Abadehella* (Leven, personal commun., 1996), and conodont data (Wardlaw, 1996), all these faunas are correlated with the upper Wordian of West Texas.

INTERPRETATIONS

The Permian Fusulinina from the Chugach Terrane described here are typically Tethyan and show that the assemblage is early Midian (late Wordian) in age (Table 1). In addition, the similarity of several species from Alaska to other fusulinacean species in Washington, British Columbia, and the Tethys suggests a common origin. All of these species point to an original Permian area of accumulation in the tropical, western Paleopacific Ocean. The alga shows that the water was very shallow, so it seems likely that the limestone accumulated on a volcanic edifice, perhaps as an atoll.

The radiolarian cherts of the McHugh and Uyak Complexes, which span mid-Triassic through mid-Cretaceous time and probably extend down into the Paleozoic, record pelagic and/or hemipelagic deposition in an open-ocean environment. Accordingly, we suggest that the limestone bearing the Permian Fusulinina travelled the open Paleopacific Ocean during the Late Permian and well into the Mesozoic before being accreted to Alaska. The Seldovia quadrangle and Kodiak Island localities represent the farthest north such Permian Tethyan limestone blocks in North America were carried and they may have been among the last of such blocks to have been accreted to North America.

Although some of the conglomerate clasts in the McHugh Complex could have been derived from the Wrangellia terrane, as suggested by Nelson et al. (1986), the limestone block containing Tethyan fossils reported here was not; the Wrangellia terrane contains only non-Tethyan fusulinids (Petocz, 1970) and corals (Rowett, 1969; Stevens, in prep.)

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FIGURE 4—Permian fusulinids from the McHugh Complex, field sample number 93ADw41A, except for *1* and *4* from sample 93ADw41B. *1,4*, *Yabeina* sp. A, ×25, ×70; *2,3,5–8*, *Yabeina* sp. B; *2,8* ×15, *3* ×90, *5* ×10, *6* ×25, *7* ×40; (*2,3*, same specimen; *5–7*, same specimen).

TABLE 1—Correlation of the fusulinid faunas in the McHugh Complex with those of well-studied Midian localities elsewhere.

Stage	Region: Dzhagadzur section, Transcaucasia	Kubergandy section, South Pamirs	Akasaka section, Japan	Bystraya River locality, Koryakia terrane	Cache Creek terrane, British Columbia & Northwestern Washington	Guadalupe Mts., West Texas	Chugach terrane, Alaska
Capitanian (Upper Midian)	*Abadehella* sp. *Colaniella* cf. *minima* *Kahlerina globiformis* *Reichelina minuta* *Rauserella* sp. *Dunbarula* sp. *Neoschwagerina pinguis* *Chusenella minuta*	*Dunbarula mathieui* *Lantschichites minima* *Neoschwagerina katoi* *Yabeina opima* *Lepidolina multiseptata* *Chusenella ishanensis*	*Kahlerina* sp. *Neoschwagerina minoensis* *Yabeina globosa* *Lepidolina multiseptata* *L. shiraiwensis*	*Reichelina media* *Rauserella fujimotoi* *Yabeina globosa* *Y. ampla*	*Codonofusiella duffelli* *Neoschwagerina insularis* *Yabeina ampla* *Y. columbiana* *Y. obesa* *Lepidolina minuta* *Lepidolina multiseptata* *Lepidolina dunbari* *Neosumatrina cylindrica* *Chusenella royandersoni*	*Codonofusiella paradoxica* *Rauserella erratica* *Leella bellula* *Polydiexodina capitanensis*	—
	Khachik Fm.	Karasin Fm., upper portion (Beds 47–49)	*Yabeina globosa* zone	*Yabeina globosa* beds		Capitanian	
Upper Wordian (Lower Midian)	*Colaniella* sp. *Codonofusiella* sp. *Chusenella abichi* —— *Abadehella biconvexa* *Kahlerina* sp. *Reichelina* sp. *Rauserella* sp. *Dunbarula nana* *Chusenella referta* *Sumatrina longissima*	*Abadehella* sp. *Kahlerina* sp. *Dunbarula schubertellaeformis* *Rauserella* sp. *Yabeina archaica* *Neoschwagerina margaritae* *Sumatrina annae*	*Dunbarula nana* *Neoschwagerina haydeni* *Gifuella gifuensis* *Gifuella amicula* *Yabeina ozawai*	*Dunbarula nana* *Chusenella* cf. *sinensis* *Colania kwangsiana* *Neoschwagerina hanaokensis* *Verbeekina verbeeki* *Pseudodoliolina ozawai*	*Abadehella* sp. *Kahlerina* sp. *Dunbarula schubertellaeformis* *Ogbinella cascadensis* *Neoschwagerina pecularis* *Colania danneri* *Yabeina nakinensis* *Y. cordillerensis* *Y. moncropensis* *Verbeekina americana* *Pseudodoliolina oliviformis* *Chusenella atlinensis* *Chusenella referta*	*Abadehella* sp. *Rauserella* sp. *Leella fragilis* *Parafusulina kingorum* *P. wordensis* —— *Rauserella* spp. *Leella fragilis* *Parafusulina lineata* *P. deliciasensis* *P. sellardsi*	*Abadehella* sp. *Kahlerina* sp. *Codonofusiella* sp. *Dunbarula* sp. *Yabeina* sp. A *Yabeina* sp. B *Pseudodoliolina oliviformis* *Metadoliolina* sp. *Sumatrina*? sp. *Verbeekina* sp. *Chusenella* ex gr. *atlinensis*
	Arpa Fm.	Karasin Fm., lower portion (Beds 44–46)	*Neoschwagerina margaritae* zone	*Neoschwagerina hanaokensis*, *Colania kwangsiana* beds		Upper Wordian	
Davydov, 1994	Kotlyar et al., 1989	Chediya et al., 1986; Davydov, 1994	Honjo, 1959; Skinner and Wilde, 1966b	Davydov et al., 1996	Thompson et al., 1950; Skinner and Wilde, 1966a; Ross, 1971	Dunbar and Skinner, 1936; Wilde, 1990	Authors herein

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THE FIRST OCCURRENCE OF THE BURGESS SHALE DEMOSPONGE *HAZELIA PALMATA* WALCOTT, 1920, IN THE CAMBRIAN OF UTAH

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ABSTRACT—A single specimen of *Hazelia palmata* Walcott, 1920, was collected from the Middle Cambrian Marjum Formation near Marjum Pass, in the central House Range, western Utah. This is a first occurrence of the species outside the Burgess shale region of British Columbia, Canada. The flattened oval impression of the monaxonid demosponge shows characteristic tufts and spicule structures of the species.

INTRODUCTION

A SINGLE specimen of the Middle Cambrian sponge, *Hazelia palmata* Walcott, 1920, was collected from the middle part of the Marjum Formation in section 17, (unsurveyed), 610 m north and 275 m west of the southwest corner of section 16, T18S, R13W, in western Millard County, Utah (Figure 1). The sponge locality is in interbedded shale and limestone 185-200 m above the base of the Marjum Formation (Figure 2). Hintze and Robison (1975) summarized Middle Cambrian stratigraphic relationships of units in the House Range and adjacent ranges in western Utah.

White Hill Quarry, approximately 25 meters east of the sponge locality, is at about the same stratigraphic level in the Marjum Formation. It produced abundant carpoid echinoderms, an eocrinoid (Ubaghs and Robison, 1985), and several edrioasteroids (Sprinkle, 1985) in association with a moderately diverse assemblage of arthropods, hyolithids, brachiopods, sponges, and algae, (Ubaghs and Robison, 1985, p. 2). The specimen of *Hazelia* is an additional element to the fauna known from the general stratigraphic sequence. No other fossils occur on the small slab with the sponge. The trilobites *Modocia laevinucha* Robison, 1964, and *Hemirhodon amplipyge* Robison, 1964, and the phyllocarid *Tuzoia guntheri* Robison and Richards, 1981, were collected from the locality. These and other forms from the stratigraphic section, according to Ubaghs and Robison (1985, p. 2), indicate that rocks from which the sponge came are included in the middle *Ptychagnostus punctuosus* Interval-zone of the upper Middle Cambrian (Robison, 1984).

The interbedded dark, fine-grained limestone and shale of the Marjum Formation in the Marjum Pass area and the White Hill Quarry area accumulated as a deeper shelf-basin lithofacies, as documented by Brady and Koepnick (1979) and Rees (1984).

The sponge may have been swept into the basin environment as part of a turbidite accumulation. Ubaghs and Robison (1985, p. 3) indicated that the interbedded shale and limestone of the middle part of the Marjum Formation appear to represent accumulations of shale interupted by periodic influxes of fine-grained carbonate sediments. They characterize the section as of a moderately deep basin environment. Alignment of the carpoids in nearby areas suggested to Ubaghs and Robison (1985) that the sea bottom experienced considerable current action at the time of burial of those fossils, in environments somewhat similar to Silurian "smothered-bottom assemblages" described by Brett (1983). These latter associations accumulated on a gently sloping seafloor, below wavebase, influenced by storm-generated sediments, and such appears to be the environment represented by the Cambrian sponge-bearing rocks.

The figured specimen is USNM 480466 in the U.S. National Museum, Washington D.C.

SYSTEMATIC PALEONTOLOGY

Class DEMOSPONGEA Sollas, 1875
Subclass CERACTINOMORPHA Lévi, 1956
Order MONAXONIDA Sollas, 1883
Family HAZELIIDAE De Laubenfels, 1955
Genus HAZELIA Walcott, 1920
HAZELIA PALMATA Walcott, 1920
Figure 3.1–3.4, 4

Hazelia palmata WALCOTT, 1920, p. 282–283, Pl. 69, figs. 1, 1a–c; Pl. 76, fig. 2; DE LAUBENFELS, 1955, p. E38, fig. 18.4; RIGBY, 1986, p. 36–38, Pl. 11, figs. 1-8, text-fig. 19I.

Diagnosis.—"Low obconical sponges in which the skeleton is made of irregular anastomosing, dominantly radial tracts, composed of sub-parallel to echinating oxeas in the fine dermal net. Tracts bifurcate and occasionally cross between dominantly radiating tracts, which are approximately 0.2–0.3 mm in diameter and spaced 0.5–1.0 mm apart. Margin hirsute with tracts up to 2 mm long beyond the main sponge. Oxeas 0.02 mm across and up to 0.6 mm long; axial spicules longest. Echinating oxeas